Chapter 6
Infiltration BMPs

6.1 General Criteria

IMPORTANT Performance Criteria for Projects in the Direct Watershed of a Lake Where the Phosphorus Standard is Applied

When used to meet phosphorus allocations in lake watersheds, adjust the sizing of the infiltration system in accordance with Volume II of this manual.

6.1.1 General Description

Infiltration measures control stormwater quantity and quality, by retaining all or part of runoff on-site and discharging it into the ground. Infiltration is designed to occur at the surface (as in infiltration basins and to a degree vegetated swales and buffers), or in subsurface systems (e.g., infiltration trenches and infiltrators).

The basic function of an infiltration system is to remove a portion of runoff from the total runoff volume of the site and treatment comes about through absorption, straining, microbial decomposition in the soil and trapping of particulate matter within pretreatment areas. Pretreatment to remove sediments grease and oils is required prior to discharge to the infiltration measure. Possible pretreatment measures include filter strips, swales with check dams, sand filters, sediment traps, grease and oil traps, and sediment basins.

Groundwater does risk contamination with infiltration practices and some long-term studies of pollutant migration through soils beneath infiltration practices have shown a downward movement of pollutants (Schueler, 1987; MPCA, 1989). Possible excep-

Chapter Contents:

tions include soluble pollutants such as nitrate, chloride, and gasoline (Schueler, 1987). More recent studies have documented the extent of groundwater and soil contamination at various facilities and provide specific guidance for varying contamination risks. See, for example, Pitt (1994), Wilde (1994), National Research Council (1994) and Miller (1996). Infiltration systems should not be used if the intercepted runoff is anticipated to contain pollutants that can affect groundwater quality, such as hydrocarbons, nitrate, and chloride.

This manual describes three common Infiltration BMPs, each of which is appropriate for specific situations. These types include:

- Dry Well: This infiltration BMP is used to temporarily store and infiltrate prefiltered runoff from a very limited contributing area.

- Infiltration Trench: This BMP is suitable for treating runoff from small drainage areas (less than 10 acres). Installations around the perimeter of parking lots, between residential lots, and along roads are most common.

- Infiltration Basin: This BMP is suitable for treating and controlling runoff from drainage areas of 5 to 50 acres in size. Installations serving a large commercial development, a residential subdivision, an industrial subdivision, or a gravel-mining site are most common.

In addition to these infiltration techniques, there are several Low Impact Design (LID) techniques that rely on infiltration. The major difference is that the LID techniques use smaller infiltration systems to disperse infiltration throughout a site, rather than an end-of-pipe technique such as the infiltration trench and basin.

IMPORTANT
Performance Criteria

Infiltration areas must retain a runoff volume equal to 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the subcatchment's landscaped developed area and infiltrate this volume into the ground.

6.1.2 General Site Suitability Criteria

1. **Site Slopes**: Infiltration shall not be located on slopes greater than 20%.

2. **Soil Permeability:** The permeability of the soil at the depth of the base of the proposed infiltration system must be no less than 0.50 inches per hour and no greater than 2.41 inches per hour. Permeability must be shown to be reasonably consistent across the proposed infiltration area and shall be determined by in-place well or permeameter testing, by analyses of soil gradation, or other means acceptable to the department.

3. **Siting in Fill Soils:** Do not install infiltration systems in a newly filled area or a site designated as "made land" without a geotechnical evaluation of the subgrade stability and permeability rates.

4. **Industrial Sites:** Infiltration devices should not be used in manufacturing and industrial areas because of the high potential for soluble and toxic pollutants and petroleum products.

5. **Construction Sites:** Construction site runoff should not be directed to infiltration areas because of the high concentration of suspended solids, which will clog infiltration surfaces.

6.1.3 General Design and Construction Criteria

1. **Sizing:** Infiltration systems must be designed to retain a runoff volume equal to 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the subcatchment's landscaped developed area and infiltrate this volume into the ground.

2. **Site Construction:** Infiltration practices may not be used as sediment control devices during site construction. Plans must clearly indicate how sediment will be prevented from entering the infiltration device during construction.

3. **Dry Weather Effluent:** Dry weather storm drain effluent should not be directed to infiltration areas due to probable high concentrations of heavy metals, pesticides, pathogens, and other pollutants.

4. **Combined Sewer Overflows:** Combined sewage overflows should not be directed to infiltration areas because of their high pathogen concentrations and high clogging potential.

5. **Snowmelt:** Snowmelt runoff from areas subject to or adjacent to road traffic or parking should not be directed to infiltration areas because of the high concentrations of salts.

6. **Soil Amendment:** If amending soils to meet permeability, the added soils must be at least six inches thick, with the bottom three inches tilled into the native soil.

7. **Stone Porosity:** A porosity value of 0.4 shall be used in the design of stone reservoirs for infiltration practices.

8. **Time for Drainage:** The infiltration system must drain completely within 72 hours following the runoff event. Complete drainage is necessary to maintain aerobic conditions in the underlying soil to favor bacteria that aid in pollutant attenuation (Schueler, 1987)

IMPORTANT
Design Tips

- Pretreatment to remove sediments is required for all infiltration systems. Pretreatment must be designed to store an annual volume of sediment.
- Soil permeability at the depth of the proposed infiltration system must be between 0.50 and 2.41 in/hr.
- Soil permeability must be determined by in-place well or permeameter testing, soil gradation or other means acceptable to DEP.
- Infiltration systems must drain completely within 72 hours following the runoff event.
- Maintenance is critical to system performance. Sediment must be removed at least annually.
- The bottom of the infiltration system must be at least three feet above the elevation of the seasonal high water table.
- Infiltration systems serving one acre or more of impervious area must be located in areas with more than five feet of saturated overburden above the bedrock surface.
- Stormwater infiltration may not affect the direction of groundwater flows.
- Infiltration of stormwater may not cause mounding.
- Overflow must be provided to a stable discharge location.
- Setback to the components of an offsite subsurface wastewater disposal system must be at least 100 feet or the setback distances may be require approval from the local plumbing inspector or the Department of Human Services' Division of Health Engineering.

and to allow the system to recover its storage capacity before the next storm event.

9. **Emergency Drainage:** A means to dewater the infiltration system in the event of failure should be provided. This will allow for easier repair of the system.

10. **Separation From Seasonal High Water Table:** The bottom of the infiltration system, including any stone layer or other material below the depth of any manufactured components of the system, must be at least three feet above the elevation of the seasonal high water table.

11. **Separation from bedrock:** Infiltration systems serving one acre or more of impervious area must be located in areas with more than five feet of saturated overburden above the bedrock surface, as measured during the seasonal low water table. This restriction does not apply to runoff from areas of non-asphalt roofing on structures in which no manufacturing or processing occurs, other than for home-based industries. Separation from bedrock and depth to the water table may be demonstrated by means of test pits, borings, or similar invasive explorations, or by non-invasive geophysical methods such as seismic surveys.

12. **Impact on Depth to Groundwater:** Infiltration of stormwater may not increase the elevation to the seasonal high water table beneath a surface-irrigation site, land-disposal area for septage or other waste, or other waste or wastewater management facility, without approval by the DEP and, if applicable, the Department of Health Human Services.

13. **Impact on Groundwater Flow:** Stormwater infiltration may not affect the direction of groundwater flows so as to impair any groundwater monitoring programs or cause the migration of existing contaminated groundwater that would result in unreasonable adverse impact on the quality of surface water, groundwater, or drinking water supplies.

14. **Mounding and Seepage:** Infiltration of stormwater may not cause effects that will adversely affect the stability of slopes in the vicinity of the activity. A qualified professional shall assess the potential for seepage and reduction in slope stability, and submit a report of findings, including logs of test borings or other subsurface explorations, modeling, or other means of analysis as determined to be necessary and applicable.

15. **Conveyance of Overflow:** Infiltration systems must include measures to convey overflow to a stable discharge location.

16. **Access:** Access to any infiltration area must be controlled during and after construction to prevent compaction of the soil. Limit access to the site to only that equipment needed to construct the infiltration system. Avoid placement of heavy objects or traffic on stone areas or chamber areas not H-20 rated.

17. **Setback from Water Supplies:** Unless otherwise approved by the DEP and the Department of Health and Human Services' Drinking Water Program, if applicable, locate the infiltration system at least 300 feet from any private water supply well, outside the delineated contributing area of a public water supply well, and as far downgradient of any water supply well as practical.

18. **Setback from Water Supply Lines:** Site the basin at least ten feet from any water supply conduit.

19. **Setback from Wastewater Disposal Systems:** An infiltration system is considered a major watercourse for the purposes of Table 700.2 of the Maine Subsurface Wastewater Disposal Rules, 144A CMR 241, for determining applicable setbacks from the relevant components of an offsite subsurface wastewater disposal system. Additional setback distances may be required by the local

plumbing inspector or the Department of Human Services' Division of Health Engineering. Allowance for lesser setbacks for onsite disposal systems or other disposal systems owned or controlled by the developer may be requested from the department, the Department of Human Services, and the local plumbing inspector. Infiltration systems must be located as far downgradient of any component of a subsurface wastewater disposal system as practical.

20. **Setback from Steep Slopes:** 50 feet from downhill slopes greater then 3:1.

21. **Setbacks from Flood Plains:** 10 feet from a 10 year floodplain.

22. **Setback from Property Lines:** At least 25 feet from the property line.

23. **Observation Wells:** Subsurface infiltration systems must have an observation well for monitoring recovery and determining when rehabilitation is necessary, unless the system uses an accessible manhole-type structure. The observation well shall be a 4-inch diameter, perforated PVC pipe fitted with a removable yet securable well cap, foot plate, and rebar anchor. Set the observation well prior to backfilling with the stone fill.

24. **Geotextile Lining:** A geotextile fabric with suitable characteristics must be placed between any stone layer and adjacent soil. The fabric will prevent the surrounding soil from migrating into the system and reducing its storage capacity. Use an appropriate geotextile design manual to choose a fabric that is compatible with the surrounding soil for the purposes stated above. The filter fabric should be free of tears, punctures, and other damage. Overlap seams a minimum of 12 inches.

25. **Stone Fill:** Stone fill shall be clean, washed, 1½ -inch to 3-inch aggregate.

26. **Sediment Pretreatment:** Pretreatment devices such as grassed swales, underdrained swales, filter strips, and sediment traps shall be provided for all infiltration systems to minimize the discharge of sediment to the infiltration system. Pretreatment structures shall be sized to hold an annual sediment loading. An annual sediment load shall be calculated using a sand application rate of 500 lbs/acre for sanding of roadways, parking areas, and access drives within the subcatchment area, a sand density of 90 lbs per cubic foot and a minimum frequency of ten sandings per year.

27. **Petroleum Pretreatment:** Infiltration systems receiving runoff from areas of asphalt or concrete paving must include sump skimmers, sorbent booms, or similar devices to remove petroleum products from runoff.

28. **Fill Placement:** Limit fill compaction to the work necessary to spread the fill to a uniform depth within the structure. Do not drive rollers or other equipment over the fill to compact it.

29. **Landscaping:** For subsurface systems, cover the fabric with twelve inches of soil and revegetate. Do not leave a depression above the infiltration system to collect water. The drip-line of any existing or newly planted trees shall not extend over the infiltration system. New trees shall be planted away from the well to account for future crown and root growth. Any newly established trees (seedlings) in the vicinity of the infiltration system shall be removed to prevent roots from intruding into the system.

To obtain an annual sediment volume, perform the following calculation:

$$\underset{\text{(acres)}}{\text{Area to be sanded}} \times 500\,\frac{\text{pounds}}{\text{acre-storm}} \div 90\,\frac{\text{pounds}}{\text{ft}^3} \times 10\,\frac{\text{storms}}{\text{year}} = \text{cubic feet of sediment/yr}$$

30. **Insulation:** Unlike wastewater disposal systems, which are less likely to freeze due to the effluent temperature and also to biological activity, the components of a stormwater infiltration system may be susceptible to freezing if located above the depth of frost penetration. The designer should consider the need for incompressible insulation for shallow system components.

6.1.4 General Maintenance Criteria

Preventive maintenance is vital for the long-term effectiveness of an infiltration system. Since infiltration is less conspicuous than most BMPs, it is easy to overlook during maintenance inspections. The following criteria apply to all infiltration systems.

1. **Fertilization:** Fertilization of the area over the infiltration bed should be avoided unless absolutely necessary to establish vegetation.

2. **Snow Storage Prohibited:** Snow removed from any on-site or off-site areas may not be stored over an infiltration area, with the exception of storage on pavement alternatives approved by the department.

3. **Monitoring and Inspections:** Inspect the infiltration system several times in the first year of operation and at least annually thereafter. Conduct the inspections after large storms to check for surface ponding at the inlet that may indicate clogging. Water levels in the observation well should be recorded over several days after the storm to ensure that the system drains within 72 hours after filling.

4. **Pollution-Control Devices:** Pollution-control devices such as oil-water separators, skimmers, and booms must be inspected regularly to determine if they need to be cleaned or replaced.

5. **Sediment Removal and Maintenance of System Performance:** Sediment must be removed from the system at least annually to prevent deterioration of system performance. The pre-treatment inlets should be checked periodically and cleaned out when accumulated sediment occupies more than 10% of available capacity. This can be done manually or by a vacuum pump. Inlet and outlet pipes should be checked for clogging. Accumulated grease and oil from separator devices should be removed frequently and disposed of in accordance with applicable state and local regulations. The system must be rehabilitated or replaced if its performance is degraded to the point that applicable stormwater standards are not met.

6. **Pretreatment Buffer Strips:** If a grass buffer strip is used in conjunction with the infiltration BMP it should be inspected regularly. Growth should be vigorous and dense. Bare spots or eroded areas should be repaired and/or re-seeded or re-sodded. Watering and/or fertilization should be provided during the first few months after the strip is established, and may periodically be needed in times of drought. Grass filter strips should be mowed regularly to prevent the uncontrolled growth of briars and weeds. Filter strips in residential or commercial areas will need to be mowed more frequently, but filter strip performance will be impaired if the grass is cut too short. Lawn clippings should be removed to prevent them from clogging the BMP.

7. **Observation Wells, Measure of Sediment Accumulation, and Points of Access for Sediment Removal:** Observation wells to determine the system's performance and access points to allow for the removal of accumulated sediment must be included in the design of infiltration systems. Dry wells and infiltration basins must have staff gauges, marked rods, or similar instrumentation to measure the accumulation of sediment and determine how quickly the system drains after a storm. The maintenance plan must indicate the expected rate of drainage

of the infiltration system and provide for removal of sediment from the infiltration system.

8. **Groundwater Monitoring:** Groundwater quality monitoring may be required as part of the system maintenance to demonstrate that pollutant removal practices are effective. Groundwater quality monitoring will generally be required for activities infiltrating water from areas of heavy turf-chemical use, such as golf courses and certain athletic fields, and large connected impervious areas, such as parking lots and runways. Groundwater quality monitoring will generally not be required for systems infiltrating water from lawn areas and other vegetated areas, residential developments, playing fields, and roofs of residential and commercial structures.

9. **Groundwater Testing:** Groundwater should be analyzed quarterly for indicator parameters such as pH, specific conductance, dissolved oxygen, and chloride. Zinc has been found to be a stabile heavy metal and should also be measured quarterly; it tends to appear anywhere from two to ten years after operation of large systems. Sampling for diesel-range and gasoline range organics, BTEX and MTBE, should be performed if draining large impervious areas of urbanized areas.

10. **Deed:** A commitment to regularly maintain privately-owned trenches will have to be legally conditioned in the property deed, development permit, or home-owner association agreement.

6.2 Types of Infiltration BMPs

6.2.1 Dry Well

A dry well is a small, stone-filled pit, or structure surrounded by stone, typically 3 to 12 feet deep, used to temporarily store and infiltrate pre-filtered runoff from a very limited contributing area. Figure 6-1 shows drawings of typical dry wells.

Runoff is stored in the structure and/or void spaces in the stone fill. Runoff enters the dry well by an inflow pipe, inlet grate, or by surface infiltration, and infiltrates through the bottom and sides of the pit. When a dry well is properly sited and designed, most runoff pollutants will become bound to the soil under the well while the water percolates to the groundwater table.

A dry well is best suited for receiving roof runoff via a building's gutter and downspout system. Because of their small size and low cost, dry wells are particularly suited for use within a subdivision of single-family homes. Except for a screen or grate at the head of the downspout, no pretreatment measures precede treatment within a dry well for roof runoff. Dry wells can also be used in combination with catch basins on roadways to promote infiltration of smaller storms, while providing conveyance of larger storms. These can be designed with deep sumps to capture sediments, while still providing for infiltrating through the walls above the sump. Dry wells are a simple and effective technique used to promote LID.

Design and Construction Criteria

In addition to the general design and construction criteria discussed in the beginning of this chapter, the following criteria must also be applied in the design and construction of dry wells.

1. **Setback from Foundations:** Locate dry wells at least 10 feet from the building foundation and at least 100 feet from buildings downslope from the device.

2. **Setback from Natural Resources:** Site the dry well at least 25 feet away from any wetland, stream, river, lake, or coastal estuary.

3. **Overflow Measures:** Design and build the dry well to include measures for controlling overflow. In a roof-drain application, a surcharge pipe can outlet to a splash block or directly onto the lawn. In a leaching catch basin, pipes can be used to connect one structure to another, allowing larger storms to be discharged as they would with standard catch basins. In any case, avoid discharging the well overflow to driveways, streets, or parking lots.

4. **Gutters and downspouts:** Construct the dry well during the installation of the roof gutters and downspouts. A coarse screen or grate should be installed at the inlet of the downspout or along the length of the gutter to prevent leaves and debris from clogging the inlet to the dry well.

5. **Inlet Connection:** The runoff diverted to the dry well should enter through below-ground pipes to avoid intercepting any sediment from surface runoff. Pipes should enter any open structure through a clamped watertight boot or be securely mortared in place where they enter the structure. Pipes should enter as close as practicable to the top of the dry well.

Maintenance

In addition to the general maintenance criteria discussed in the beginning of this chapter, the following criteria must also apply to the maintenance of dry wells. Maintenance of a dry well for roof top runoff requires cleaning the gutters of debris that may clog the downspout. If dry wells are used on single-family homes, this cleaning will usually be left to each homeowner. There is no reliable estimate about the length of time a dry well will function before clogging. It is probable that the longevity of the well is 10 to

15 years, depending on how often the gutters are cleaned, the type of roofing material, and the choice of filter fabric used to line the well.

1. **Gutter Cleaning:** Remove any leaves, seeds, and other debris from the roof's gutters every spring and every fall. A coarse screen or grate should be installed at the head of each downspout leading to the dry well. Replace the screen or grate if it is broken.

2. **Rehabilitation:** Clogging of a dry well is likely to occur at the bottom of the well. Relieve this clogging by excavating away the turf and soil over the well; removing the existing stone and perforated pipe; and rebuilding the dry well. Dig out the soil at the bottom of the dry well and replace it with a six-inch layer of clean sand. The old stone in the dry well can be reused if it is washed prior to reinstalling it in the well. To minimize the eventual cost of rehabilitation, the dry well should be located in a lawn area as close as possible to the ground surface.

6.2.2 Infiltration Trench

An infiltration trench is a stone-filled excavation used to temporarily store runoff so that it can infiltrate into the ground. There are two types of infiltration trenches: surface trenches and underground trenches. A surface trench is open at the ground surface, exposing the trench's top layer of stone. An example of a surface trench is shown in Figure 6-2. Runoff enters this trench as overland flow after pretreatment through a filter strip or vegetated buffer. Turf or pavement covers an underground trench. An example of an underground trench is shown in Figure 6-3. Runoff enters the trench in a solid pipe; it is distributed within the trench by perforated pipe. Pipes or manhole structures may be incorporated into infiltration trenches to increase the storage capacity while minimizing the footprint of the infiltration system. When a trench is properly sited and designed, most runoff pollutants will become bound to the soil under the trench while the runoff water percolates to the groundwater table.

An infiltration trench is suitable for treating runoff from small drainage areas (less than 10 acres). Installations around the perimeter of parking lots, between residential lots, and along roads are most common. Infiltration trenches can also be incorporated beneath a vegetated swale to increase its infiltration ability.

Design and Construction Criteria

In addition to the general design and construction criteria discussed in the beginning of this chapter, the following criteria must also be applied in the design and construction of Infiltration Trenches.

1. **Site Slopes:** The surface grade at the trench site should be 20% or less for an underground trench and 5% or less for a surface trench.

2. **Setback from Foundations:** Locate the trench at least 20 feet from any foundation located upslope from the trench and at least 100 feet from any foundation located downslope from the trench. Designers should always evaluate the possible effects of mounding to determine if greater setbacks are required.

3. **Setback from Natural Water Bodies:** Site the trench at least 75 feet away from any wetland, stream, river, lake, or coastal estuary.

4. **Erosion Control:** Construct the infiltration trench after the trench's drainage area is stabilized with vegetation and erosion controls are installed to prevent sediment from reaching the trench. An infiltration trench receiving flow from an unstabilized site will have its working life greatly reduced and may even clog prior to the completion of the development. The contractor should use sod to vegetate the filter strip surrounding a surface trench. If hydroseeding or hand broadcasting must be used, then the contractor should install a sediment barrier between the filter strip and trench until the filter strip is fully vegetated. The contractor should install a pretreatment drop-inlet sediment filter around the pretreatment inlet to an underground trench. Keep the inlet filter in place until the trench's drainage area is fully stabilized with pavement and vegetation.

5. **Trench Grade:** The grade of the trench bottom and trench base should be as close to 0% as possible. Always install the trench parallel to elevation contours.

6. **Filter Fabric Installation:** Line the trench with geotextile fabric so that the cloth will completely surround the stone-filled reservoir; it should extend from the bottom of the trench to within six to twelve inches of the surface. The cut width of the fabric should include sufficient material to have a twelve inch overlap at the top of the enclosed stone. If overlaps are required between rolls of fabric, then the upstream roll should lap a minimum of two feet over the downstream roll to provide a shingled effect.

Maintenance

In addition to the general maintenance criteria discussed in the beginning of this chapter, the following criteria must also be applied to maintain infiltration trenches. There is no reliable estimate about the length of time an infiltration trench will function before clogging. It is probable that the effective lifetime of a trench is 10 to 15 years, depending on the maintenance of the pretreatment BMPs, the choice of filter fabric to line the trench, and the amount of fines in the sediment load to the trench. One study (Galli, 1993) found that slightly over half were not functioning as designed within 5 years. Proper design and long term maintenance is crucial to extend the life of an infiltration trench.

1. Maintaining a Surface Trench

a. _Inlet Maintenance:_ Remove any fallen leaves and other debris from the trench's surface inlet at least every fall after leaf drop and every spring after snow melt. If left in place, the trash and leaves will clog the trench inlet.

b. _Rehabilitation:_ Clogging in a surface trench is most likely to occur near the top of the trench between the top layer of stone and the protective layer of filter fabric. Relieve this surface clogging by carefully removing the top layer of stone, removing the clogged filter fabric, installing new fabric, and replacing the top layer of stone. If the old stone is reused, it should be washed to remove any fine sediment prior to being placed back in the trench.

2. Maintaining a Subsurface Trench

a. _Inlet Maintenance:_ Check the pretreatment inlets to an underground trench at least annually and clean-out any sediment, trash, oil, and grease when these materials deplete more than 10% of the inlet structure's capacity.

b. _Rehabilitation:_ Clogging of an underground infiltration trench is likely to occur at the bottom of the trench. Relieve this clogging by excavating away any pavement, turf, and soil over the trench; removing the existing stone and perforated pipe,; and rebuilding the trench. Scarify the soil at the bottom of the trench with a tiller or dig-out this soil and replace it with a six-inch layer of sand. The old stone in the trench can be reused if it is washed prior to reinstalling it in the trench.

6.2.3 Infiltration Basin

An infiltration basin is a water impoundment, typically 3 to 12 feet deep, constructed over permeable soil to infiltrate runoff into the ground. The basin drains dry between storm events and, unlike a detention basin, is not specifically designed to release any stormwater as surface flow except for flows from larger storms. As a structural safety measure, however, the basin will usually have an emergency spillway to pass peak flows during extreme storm events. When a basin is properly sited and designed, most runoff pollutants will become bound to the soil under the basin before the runoff water percolates to the groundwater table.

When the subsoils are appropriate, an infiltration basin can be suitable for treating and controlling runoff from drainage areas of 5 to 50 acres in size. Installations serving a large commercial development, a residential subdivision, an industrial subdivision, or a gravel mining site are most common. However, some commercial and industrial sites may have contaminants that may not be treatable by soil filtration. In these cases, infiltration should be avoided in favor of other BMPs.

Figure 6-4 shows a typical infiltration basin.

Design and Construction Criteria

In addition to the general design and construction criteria discussed in the beginning of this chapter, the following criteria must also be applied in the design and construction of infiltration basins.

1. **Site Slopes:** The surface grade at the basin site should be 5% or less.

2. **Setback from Foundations:** Locate the basin at least 20 feet from any foundation located upslope from the basin and at least 100 feet from any foundation located downslope from the basin.

3. **Setback from Natural Water Bodies:** Site the trench at least 75 feet away from any wetland, stream, river, lake, or coastal estuary.

4. **Siting on Heavily Used Areas:** Sites that will receive heavy use (such as playing fields) should not be considered for infiltration basins due to the limited infiltration capacity of compacted surface soils.

5. **Off-line Siting:** A basin designed for water quality treatment is usually located off-line from the stormwater system using a flow splitter. This helps prevent the "first flush" runoff flowing into the basin from being diluted and pushed out the emergency spillway by the remaining runoff. Refer to Chapter 8, Section 8.2 for a typical flow-splitter design.

6. **Storage Volume:** The required volume of runoff to be stored in an infiltration basin consists of the volume to be treated by infiltration as outlined in the General Design Criteria applicable to all infiltration systems, plus additional capacity if it is to be used to control peak discharges from storms exceeding the magnitude of the infiltration design storm. The basin storage volume should be intentionally oversized to account for the eventual total loss of infiltration capability (Galli, 1993). To control peak rates of storm flows, only the volume in a pond above an outlet structure can be utilized on a long-term basis.

7. **Storage Depths:** Maryland (1984) indicates the maximum depth for a required recovery time can be found using the following equation:

   $d_{max} = f\ T_p$

   where d_{max}=maximum storage depth (inches)

   f=final permeability rate of the basin area (inches per hour)

   T_p=maximum allowable ponding time (hours).

   The final permeability rate is determined from field percolation tests.

8. **Emergency Spillway:** The infiltration basin should have an emergency spillway to convey overflow during extreme storm events. The spillway may be either a stone-lined or vegetated channel or a riser outlet. As a minimum, the spillway should be able to convey a flow equal to the 25-year, 24-hour peak inflow out of the basin and into a drainage way which will remain stable under these conditions while maintaining one foot of embankment freeboard above the water elevation in the basin. Spillways should be constructed on original ground (not embankment fill).

9. **Side Slopes:** Design the basin's side slopes to be no steeper than 3H:1V. The side slopes should be well-vegetated with species that can tolerate inundation and flooding for up to one week.

10. **Basin Floor:** Design the basin floor to be flat (0% slope) to develop a uniform ponding depth. This will ensure that the full infiltrative area of the basin will be used for each storm. There is some evidence that maintaining microtopography (small mounds and depressions) on the basin's floor will help delay clogging by concentrating sedimentation in the depressions. The floor should be prepared with one of the following linings.

    a. <u>*Coarse Sand or Pea Gravel:*</u> The filter layer can be replaced or cleaned when it becomes clogged. The minimum depth to bedrock or high groundwater table must be measured from the bottom of this sand or gravel layer. The sand or gravel should be at least 6 inches thick.

    b. <u>*Grass Turf:*</u> If grass is used to vegetate the basin floor, it should consist of species that can survive inundation for up to one week and still provide a dense, vigorous turf layer. Root growth by grass continually opens up new drainage paths within the soil and, so, helps delay clogging of the basin floor.

    c. <u>*A Layer of Coarse Organic Material (erosion control mix or composted mulch):*</u> These materials should be tilled into the soil. The basin floor should then be soaked or inundated for a brief period and allowed to dry. This induces the rapid decay of organic material, increasing the soil's permeability and its ability to remove soluble pollutants from the runoff.

11. **Embankment Design:** Most infiltration basins need an embankment to have sufficient storage capacity and still maintain a three-foot separation between the basin floor and the seasonal high groundwater table. The embankment must be designed to meet engineering standards for foundation preparation, fill compaction, seepage control, and embankment stability. Standards for small embankment ponds and basins can be found in Section G-2 of the Maine Erosion and Sediment Control BMPs Handbook (March 2003).

12. **Inlet Protection:** Prevention of scour at the inlet is necessary to reduce maintenance problems and prevent damage to basin floor vegetation. Provide energy dissipation at the inlet in accordance with practices outlined in the Maine Erosion and Sediment Control BMPs Handbook (March 2003).

13. **Erosion Control:** Construct the infiltration basin after its drainage area is stabilized with vegetation and erosion controls that will prevent sediment from reaching the basin. An infiltration basin receiving flow from an unstabilized site will have its working life greatly reduced and may even clog prior to the completion of the development. Thus, using an infiltration basin as a temporary sediment basin during construction is not recommended.

Maintenance

In addition to the general maintenance criteria discussed in the beginning of this chapter, the following criteria must also be applied in the maintenance of infiltration basins. Infiltration basins do not have long life spans. Sixty to one hundred percent of basins studied could no longer infiltrate runoff after five years (Schueler, 1992b). Because of the fragile nature and extremely high failure rate of infiltration basins, water quality can generally be controlled more reliably with other BMPs (Galli, 1993).

1. **Basin Inspections:** Inspections of infiltration basins should be conducted on a semi-annual basis. In addition, brief inspections should always be conducted following major storms. Timely maintenance of infiltration basins is critical, as poor maintenance practices can result in loss of infiltration capacity. Records should be kept of all maintenance operations to help plan future work and identify problem areas.

2. **Drainage Area Inspections:** Inspect the basin's drainage area semi-annually for eroding soil and other sediment sources. Repair eroding areas using appropriate erosion control BMPs immediately. Control sediment sources, such as stockpiles of winter sand, by removing them from the basin's drainage area or surrounding them with sediment control BMPs.

3. **Mowing:** A basin with a turf lining should have its side-slopes and floor mowed at least twice a year to prevent woody growth. Mowing operations may be difficult since the basin floor may remain wet for extended periods. If a low maintenance vegetation is used, basin mowing can be performed in the normally dry months. Clippings should be removed to minimize the amount of organic material accumulating in the basin.

4. **Pedestrian Access:** Limit access to turf lined basins to passive recreational activities (such as an employee lunch area). Do not use the basin for a playing field, as heavy foot traffic can compact the soil surface.

Selected References

Galli, John. 1993. *Analysis of Urban BMP Performance and Longevity.* Metropolitan Washington Council of Governments. Washington, D.C.

Grischek, T., Nestler, W., Piechniczek, D., and Fischer, T., 1996, Urban groundwater in Dresden, Germany; Hydrogeology Journal v. 4, n. 1, pp. 48 - 63

Hiscock, K.M, Rivett, M.O., and Davison, R.M. (eds), 2002, Sustainable Groundwater Development, Geological Society, London, Special Publications 193, 352 p.

Kivimäki, A.-L., and Suokko, T., 1996, Artificial Recharge of Groundwater: Proceedings of an International Symposium, Nordic Hydrological Programme Report n. 38, 309 p.

Maine DEP. 2003. *Maine Erosion and Sediment Control BMPs.* Bureau of Land and Water Quality and Maine Department of Environmental Protection.

Maryland Department of the Environment. 1984. *Maryland Standards and Specifications for Stormwater Management Infiltration Practices.* State of Maryland Department of the Environment, Sediment and Stormwater Administration. Annapolis, MD.

Miller, S. A., Lackaff, B., and Galle, B, 1996, Identification of groundwater impacts from stormwater injection and infiltration using direct and indirect methods, p. 11 - 22, Proceedings, Groundwater Protection Council Annual Forum, 224 p.

MPCA. 1989. *Protecting Water Quality in Urban Areas: Best Management Practices for Minnesota.* Minnesota Pollution Control Agency, Division of Water Quality, St. Paul, Minnesota.

National Research Council, 1994, Ground Water Recharge Using Waters of Impaired Quality, National Academy Press, Washington, D.C., 283 p.

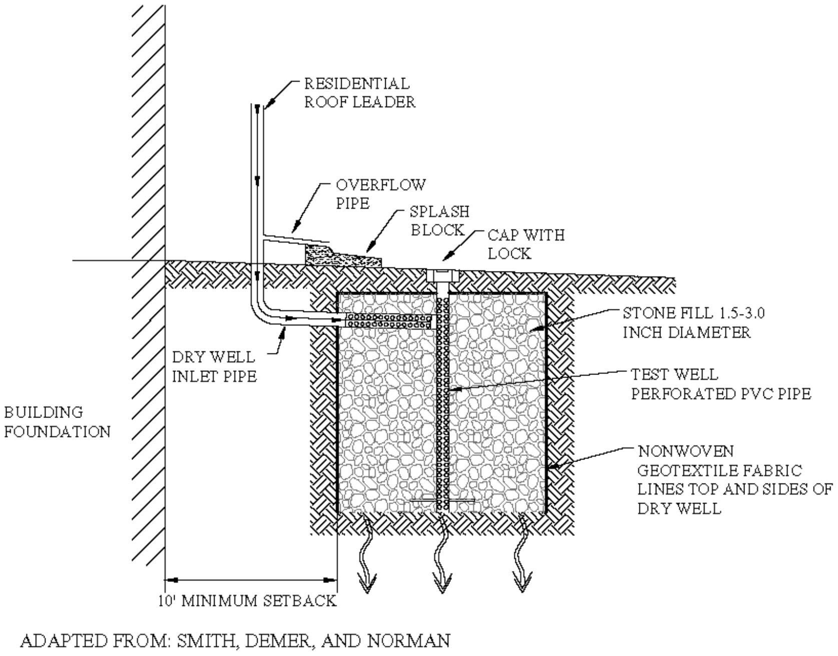
Pitt, R., Clark, S., and Parmer, K., 1994, Potential Groundwater Contamination from Intentional and Nonintentional Stormwater Infiltration; EPA Project Report EPA/600/R-94/051, 187 p.

Schueler, T.R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Metropolitan Washington Council of Governments, Washington DC.

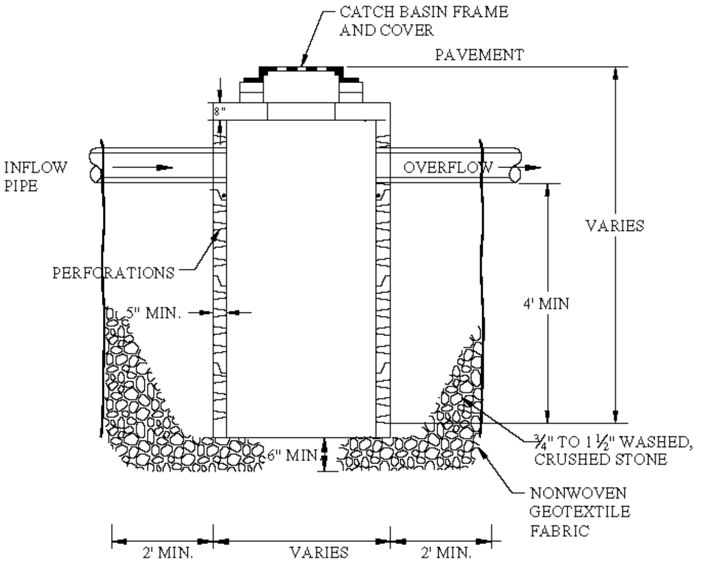
Schueler, T.R, P.A. Kumble, and M.A. Heraty. 1992a. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Metropolitan Washington Council of Governments, Washington DC.

Tourbier, J.T. and R. Westmacott. 1981. *Water Resources Protection Technology: A Handbook of Measures to Protect Water Resources in Land Development.* Urban Land Institute, Washington, D.C.

Wilde, F.D., 1994, Geochemistry and Factors Affecting Ground- Water Quality at Three Storm-Water-Management Sites in Maryland, Maryland Geological Survey Report of Investigation No. 59, 201p.



DRYWELL WITHOUT STRUCTURE



DRYWELL WITH STRUCTURE

FIGURE 6-1. TYPICAL DRYWELL

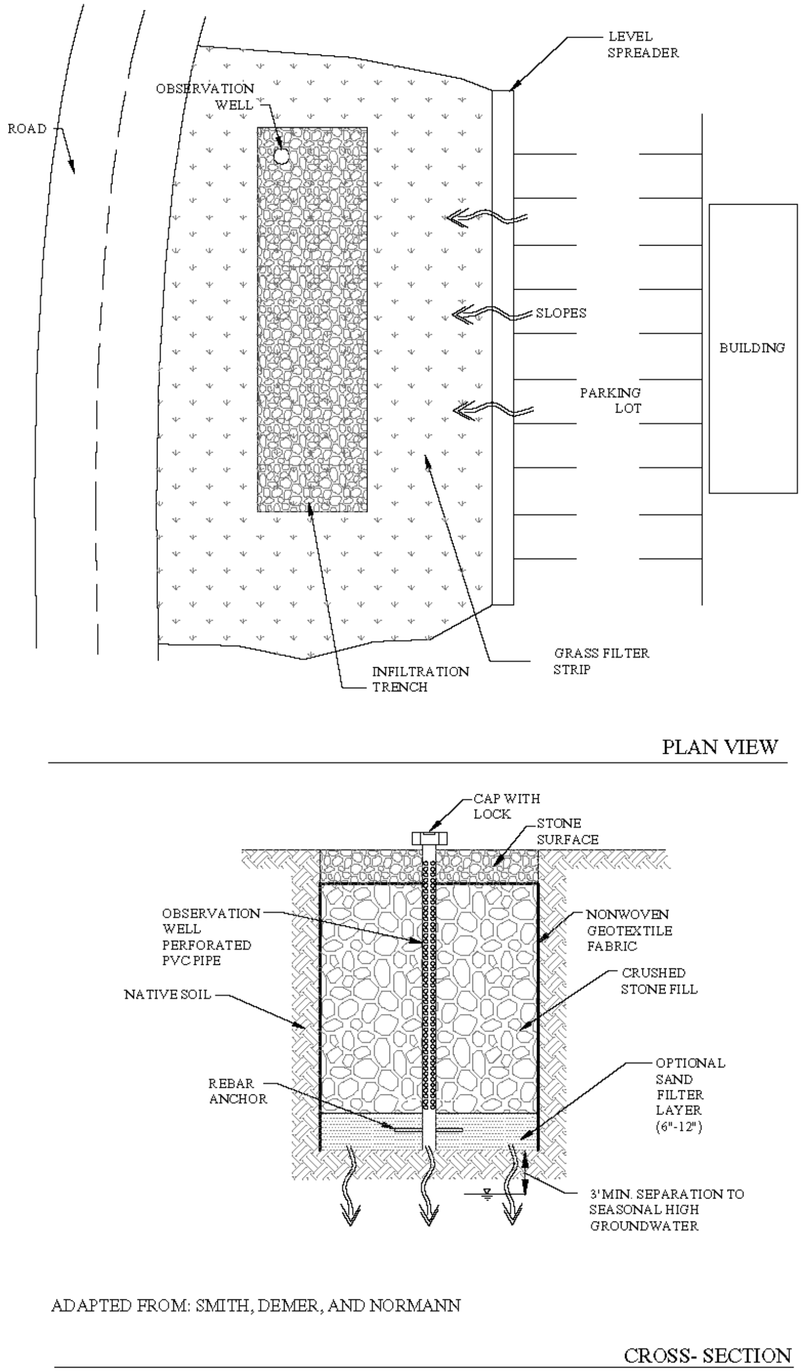


FIGURE 6-2. TYPICAL SURFACE INFILTRATION TRENCH

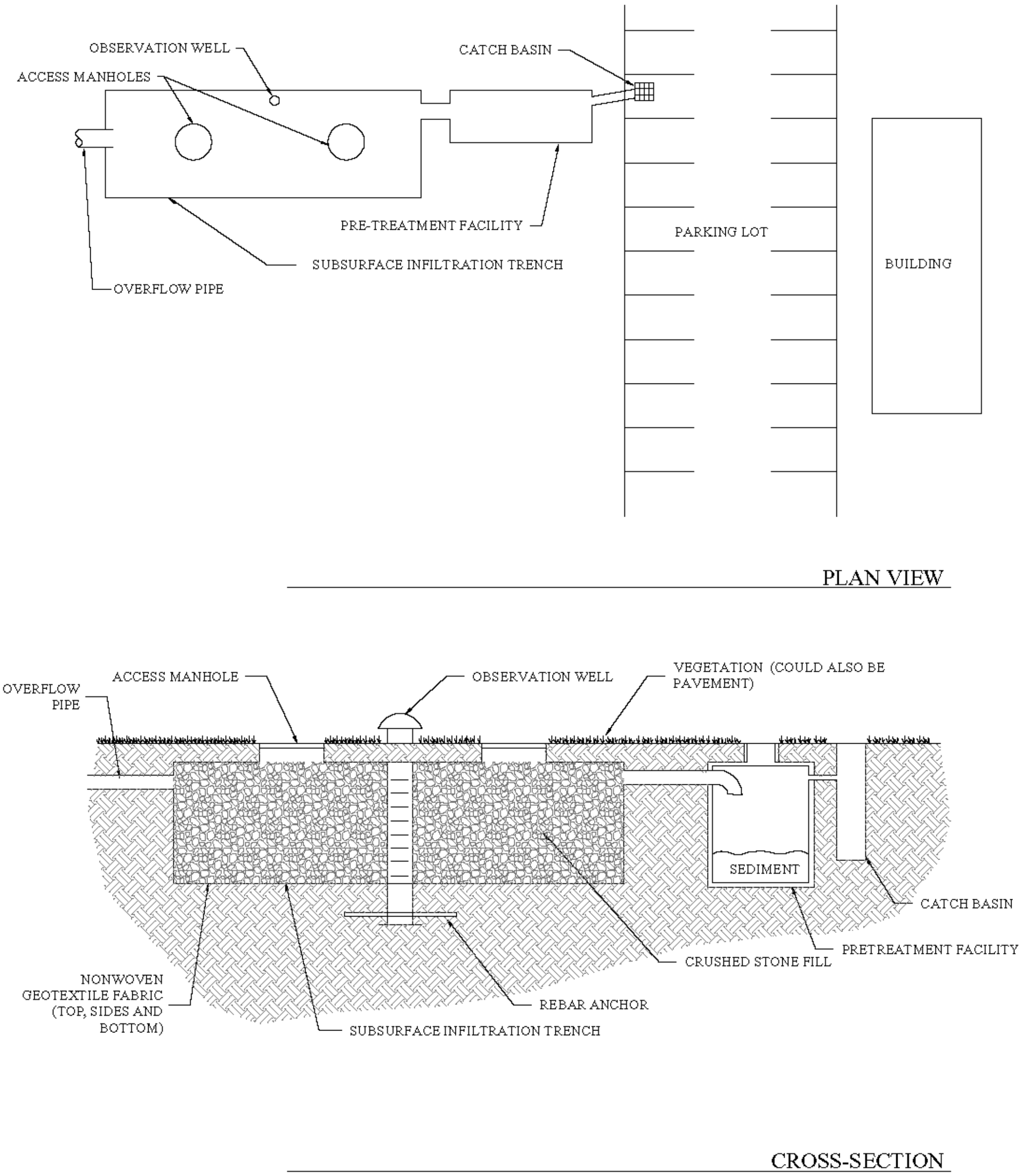


FIGURE 6-3. TYPICAL SUBSURFACE INFILTRATION TRENCH

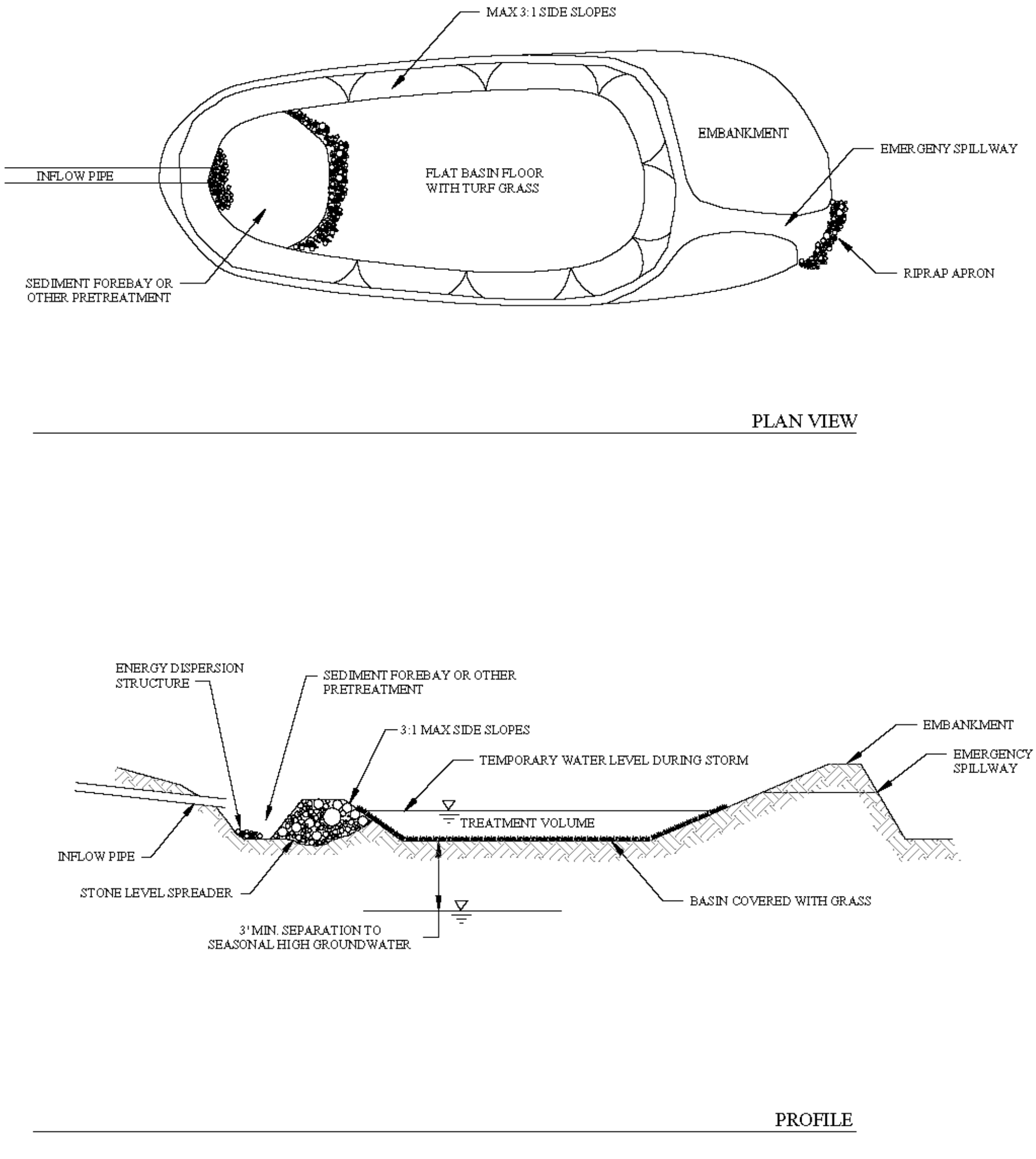


FIGURE 6-4. TYPICAL INFILTRATION BASIN